



Department of Navy Jet Noise Reduction Project Overview

**Partners in Environmental Technology
Technical Symposium & Workshop**

1 December 2010

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14. ABSTRACT High performance military aircraft represent the single largest noise source for Sailors on board aircraft carriers resulting in health issues, compromised operations and costly litigation. Unfortunately, tactical aircraft have not been able to leverage much of the available significant noise reduction technologies from commercial aircraft due to their low bypass ratio jet engines and resulting high temperature, high velocity exhaust streams. Tactical aircraft noise remains a problem from both community noise and personnel exposure perspectives. In response to the problem and recent Senior Leadership direction, the Office of Naval Research initiated the Jet Noise Reduction (JNR) Project as part of the Noise-Induced Hearing Loss (NIHL) Program. The JNR Project?s over-arching objective is to realize and transition significant jet noise reduction technologies through coordinated S&T efforts. This objective will be accomplished through establishing a sustained S&T effort in fundamental jet noise understanding, predictive capability and measurement/validation capability and through developing, demonstrating and transitioning jet noise reduction technologies in support of the Warfighter and the Community. In fiscal year 2010, initial funding was allocated to support the basic program structure and for the two main tasks given high priority?developing a physics-based understanding of jet noise and developing standards to facilitate high quality jet noise measurements. An overview of the JNR Project will be presented as well as some preliminary results and a strategic outlook.		
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DEPARTMENT OF NAVY JET NOISE REDUCTION (JNR) PROJECT

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VFA-82
USS Theodore Roosevelt (CVN 71)

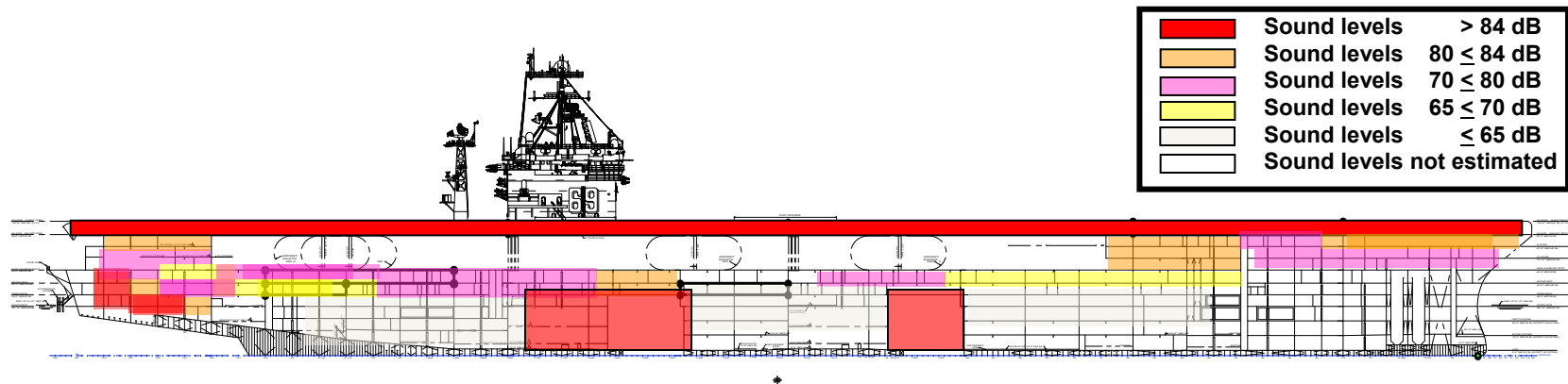
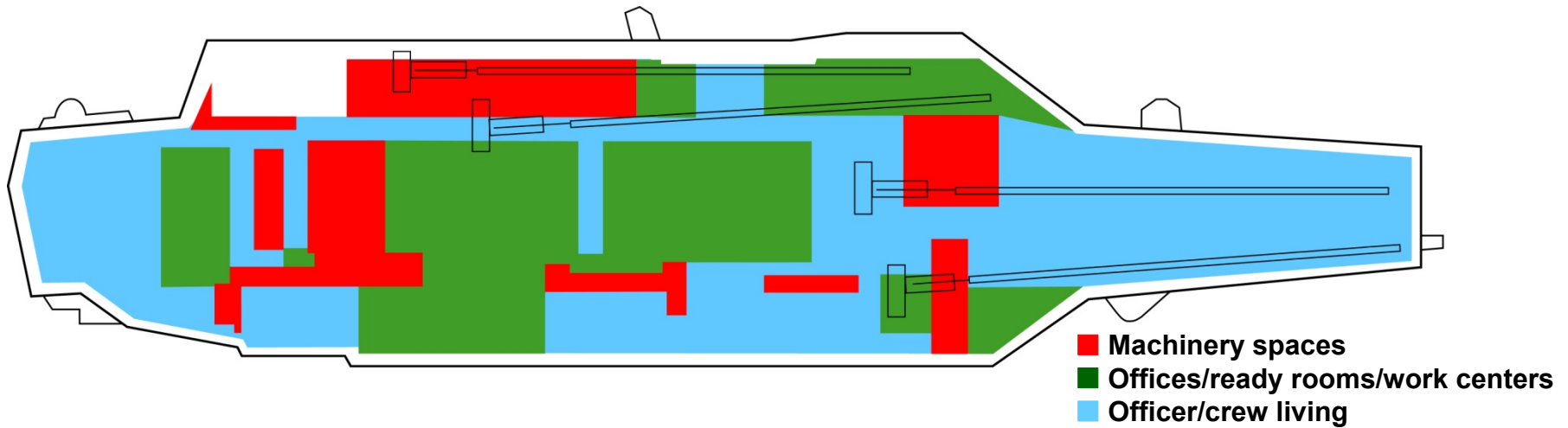


BACKGROUND



Noise Induced Hearing Loss

Jet Noise Reduction





MOTIVATION

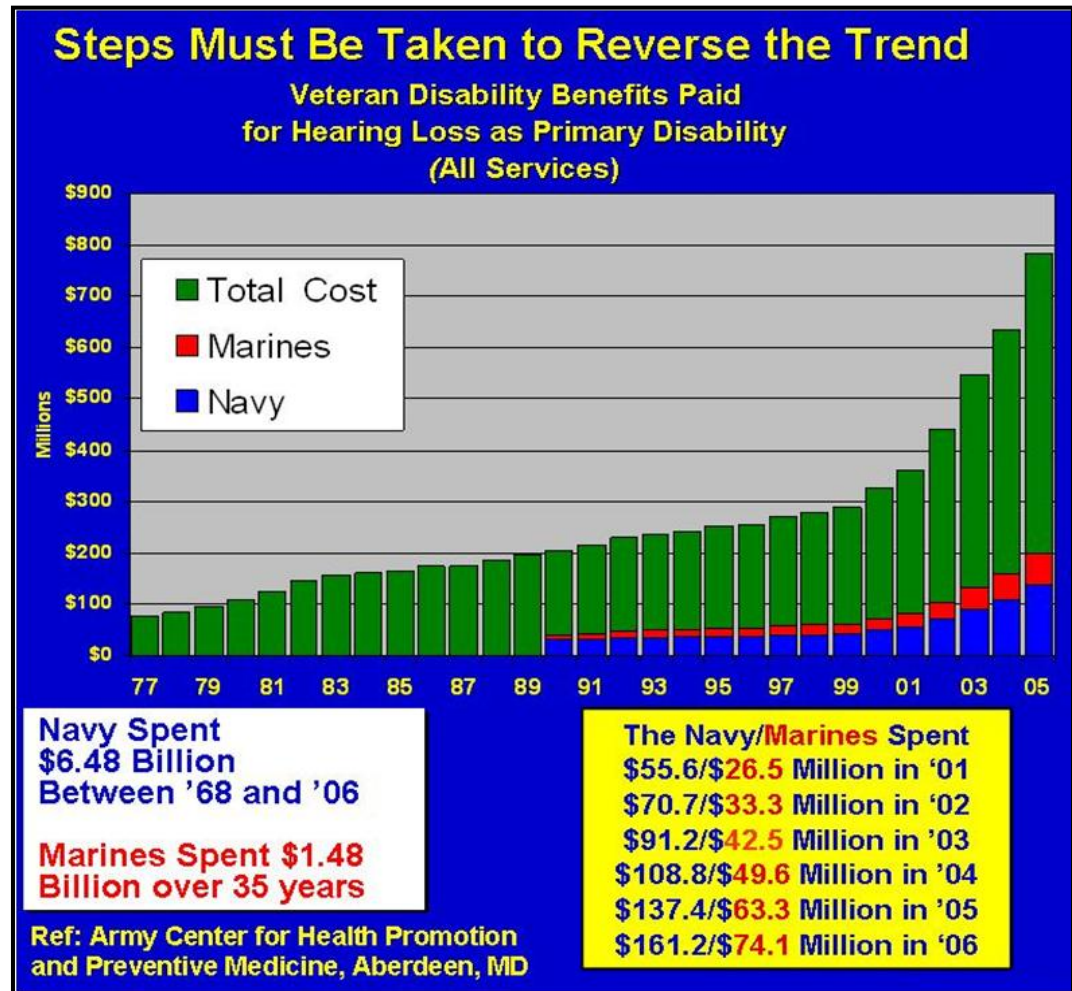


Noise Induced Hearing Loss

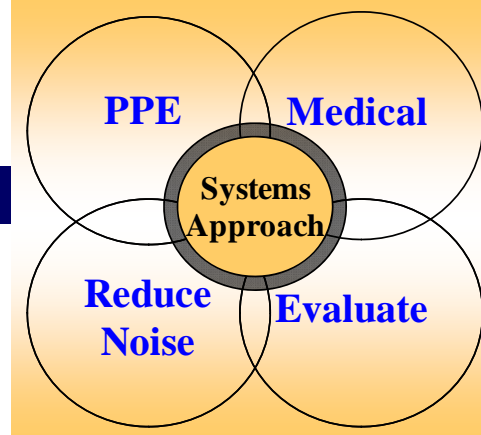
- **U.S. Department of Veterans Affairs (VA) spending \approx \$1B/year for hearing loss cases**

- Approximately 28% of claims are for current or former DON personnel
- No data exists correlating hearing loss claims to flight deck noise exposure
- Current approach consisting of personnel wearing in-canal and over the ear protective gear and limiting exposure time is inadequate

(Naval Research Advisory Committee Report on Jet Engine Noise Reduction April 2009)



NIHL/JNR GUIDANCE



Noise Induced Hearing Loss Program

2007: ASN(RD&A) request to address hearing loss prevention



THE ASSISTANT SECRETARY OF THE NAVY
Research Development and Acquisition
1000 Navy Pentagon
Washington DC 20350-1000
OCT 22 2007

MEMORANDUM FOR COMMANDER NAVAL SEA SYSTEMS COMMAND
COMMANDER NAVAL AIR SYSTEMS COMMAND
COMMANDER SPACE AND NAVAL SYSTEMS COMMAND
COMMANDER NAVAL FACILITIES COMMAND
CHIEF OF NAVAL RESEARCH
COMMANDER MARINE CORPS SYSTEMS

2008: ASN(RD&A), ASN(I&E), CNR approval of FY09-17 NIHL roadmap

SUBJECT: Hearing Loss Prevention for Naval Personnel

I am concerned that permanent hearing loss by Department personnel increase and planned Naval systems will produce noise levels that can result in permanent hearing loss. I consider hearing loss prevention to be a critical readiness, safety, health, and quality of life that requires continuous focus by all leaders at all levels.

The attachment lists actions for specific organizations. I expect each organization to take an active role in efforts to address hearing protection. DASN Management, Budget, will coordinate your responses.

I look forward to recommendations that will allow us to deploy systems that meet operational needs while protecting the health and well being of our sailors, Marines, and civilian workforce.

Delores M. Etter
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Ser. 34/004

MEMORANDUM FOR ASSISTANT SECRETARY OF THE NAVY (RESEARCH DEVELOPMENT AND ACQUISITION)

Via: ASSISTANT SECRETARY OF THE NAVY (INSTALLATIONS AND ENVIRONMENT)

Subj: RECOMMENDATIONS FOR THE PREVENTION AND TREATMENT OF NOISE-INDUCED HEARING LOSS

Ref: (a) ASN(RD&A) memo of 22 Oct 07

Encl: (1) White paper entitled, "Recommendations for the Prevention and Treatment of Noise-Induced Hearing Loss"
(2) PowerPoint brief entitled, "Recommendations for the Prevention and Treatment of Noise-Induced Hearing Loss"

1. The Office of Naval Research, in response to requests that have been developed, executed, and/or participated in a series of workshops aimed at addressing the problem of Noise-Induced Hearing Loss (NIHL). As a result, a comprehensive list of recommendations has been compiled for Navy-wide consideration (enclosure (1)). In addition, an ONR-specific roadmap and applied research endeavors that should be undertaken to address NIHL may be found in enclosure (2).

2010: VCNO Memo to Navy Surgeon General on Navy Noise Reduction



DEPARTMENT OF THE NAVY
VICE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON DC 20350-2000

IN REPLY REFER TO:
5100
Ser. NJ9/100103001
5 Jan 10

MEMORANDUM FOR SURGEON GENERAL OF THE NAVY

Subj: NAVY NOISE REDUCTION

1. On 30 November, I hosted a Navy Noise Reduction discussion which highlighted the need for increased oversight and rigor in the Navy's overall hearing conservation and noise reduction efforts.

2010 VCNO MEMO: ... "In consultation with the Naval Air Systems Command, initiate a long-term research program to obtain the needed understanding of the physics of jet noise"



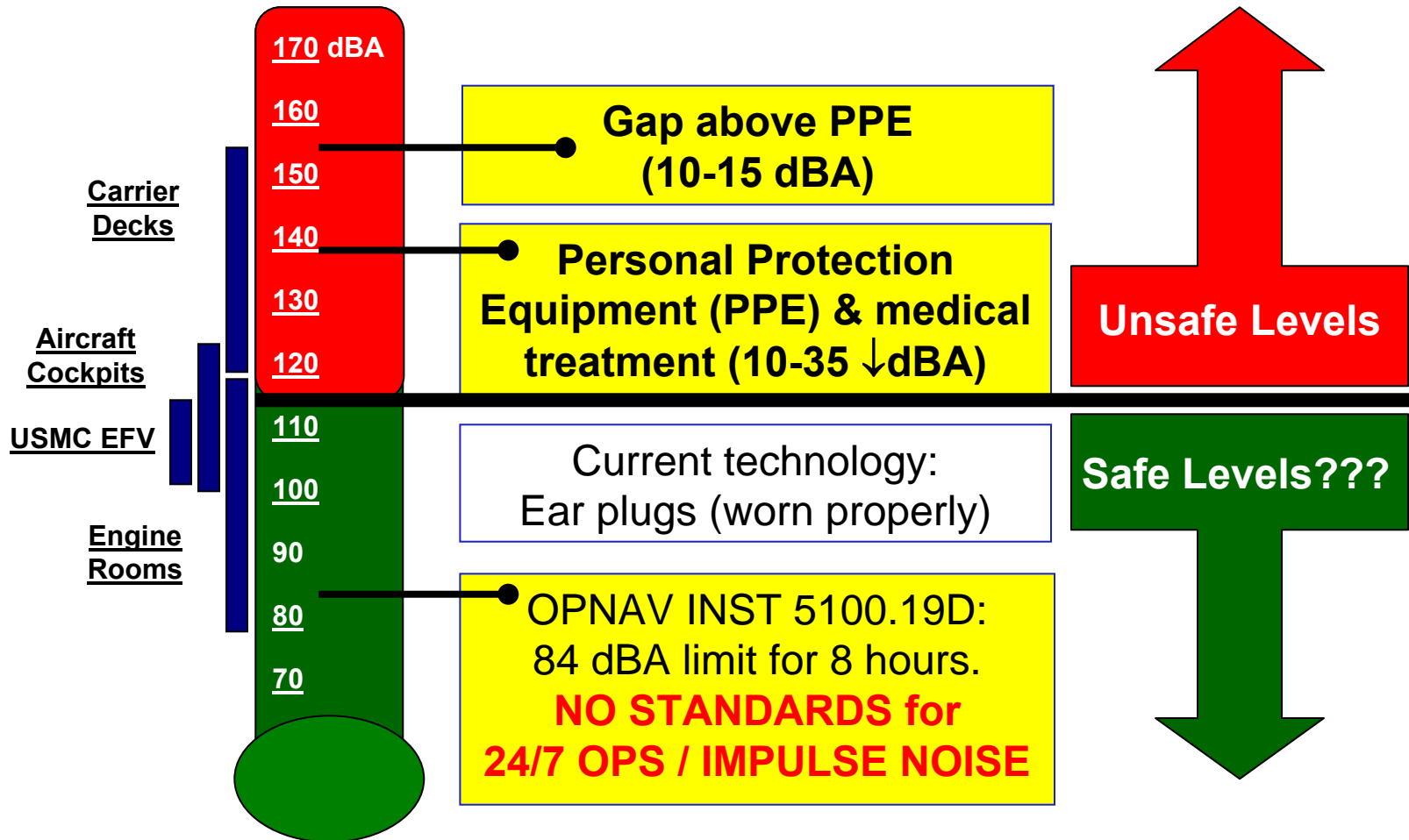
Noise Thermometer



Noise Induced Hearing Loss

Jet Noise Reduction

Current Operational Environments





Department of Navy Jet Noise Reduction Strategy

Issues/Problems with Jet Noise:

– Health Issues Due to Near-Field

- Hearing Loss/Tinnitus
- Temporary Threshold Shifts
- Non-auditory

– Community Issues Due to Far-Field During

- Takeoff
- Cruise
- Approach

**155 dB flight deck noise
with protection only up
to 140 dB**

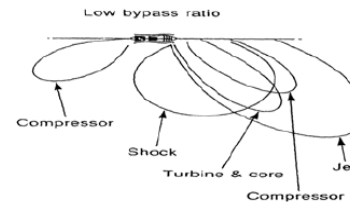
Objective:

- Realize and Transition Significant Jet Noise Reduction Technologies through Coordinated S&T Efforts

Approach:

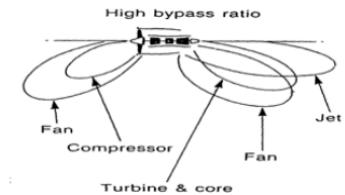
- Establish Sustaining S&T in Fundamental Jet Noise Understanding, Predictive Capability and Measurement/Validation Capability
- Develop, Demonstrate and Transition Jet Noise Reduction Technologies
 - Near-term technologies (e.g. chevrons) delivering -3dB
 - Mid-term technologies achieving -5dB (e.g. optimized nozzle expansion through independent nozzle throat and exit area control)
 - Further-term technologies for -10dB reduction (e.g. variable/adaptive cycle engines, integrated propulsion/airframe designs for noise reduction)

Low Bypass Ratio (Fighter) Engine Noise is Dominated by Jet Effects



Military

Jet noise is a strong function of velocity
Mixing devices to reduce velocity would impact thrust, weight, signature, cost, etc
No noise restriction requirements



Commercial

Velocity reduced as bypass ratio increases
Nacelle treatments targeted towards dominant turbo machinery noise
Noise regulations drive reduction

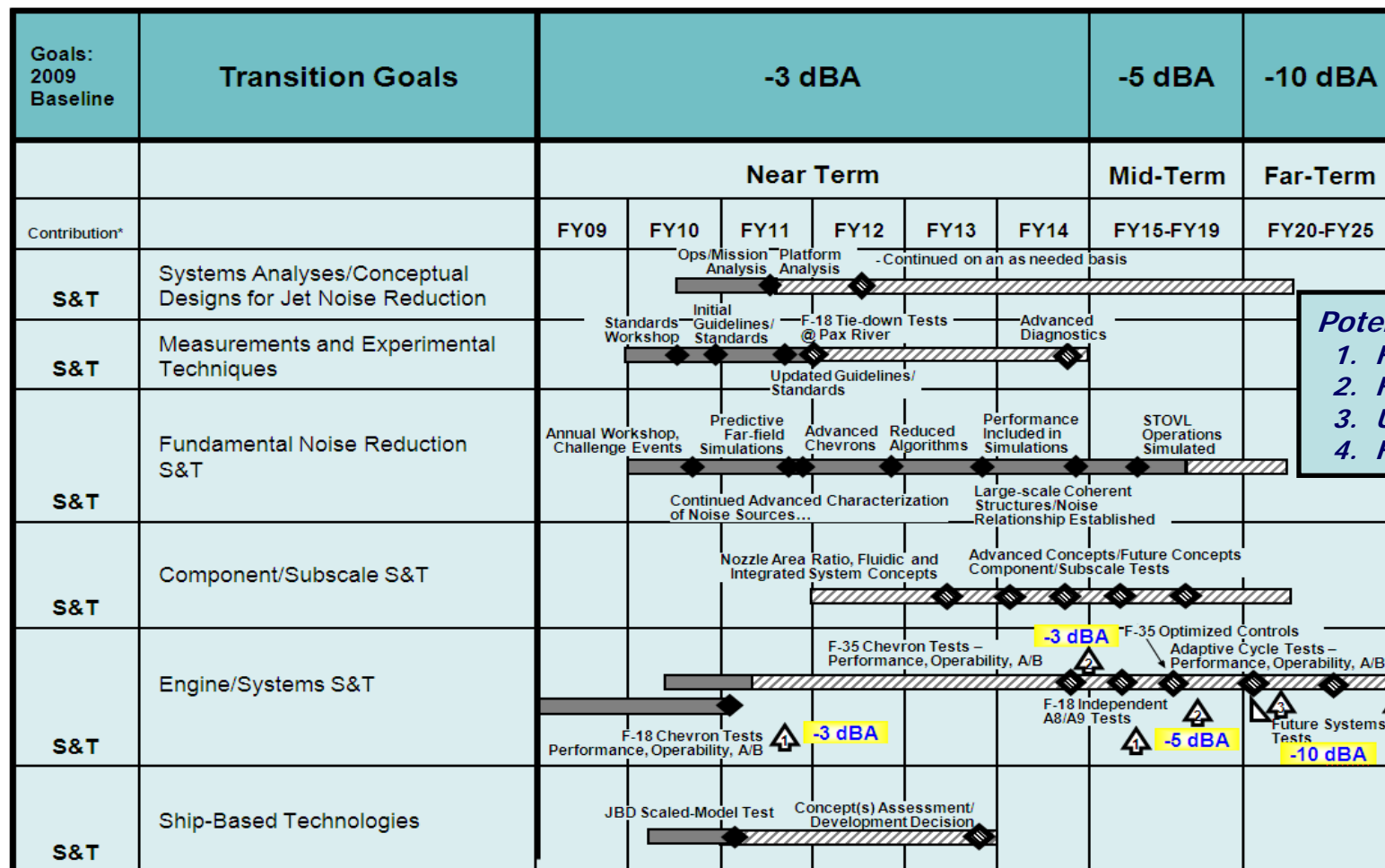


DON Leads a Tri-Service Effort at Reducing Jet Noise



Department of Navy Jet Noise Reduction S&T Roadmap

(rev. 21 June 2010)



◆ –Demos/Events ■ –S&T ◆ –Proposed Demos/Events ▨ –Unfunded S&T ▲ –Transition ▴ –Tech Enabler

JET NOISE REDUCTION S&T MISSION STATEMENT: Through long-term research, understand the physics of jet noise, identify materiel/non-materiel solutions to reduce noise, and develop and transition the technologies in support of the Warfighter and the Community



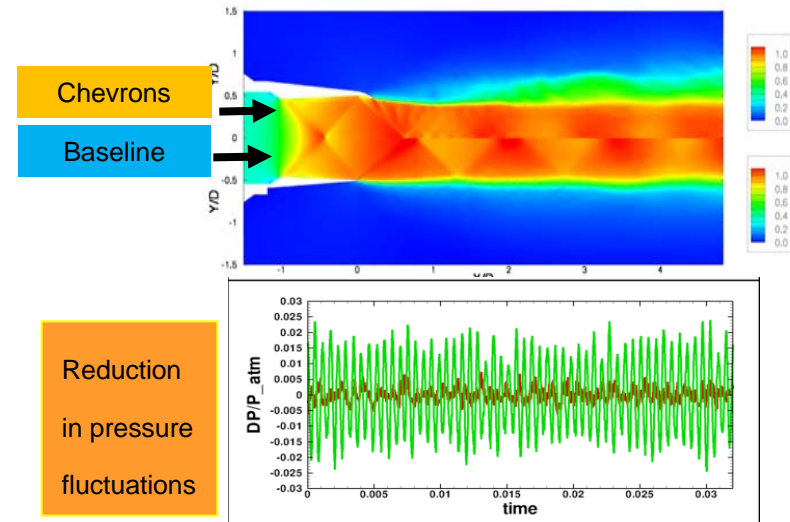
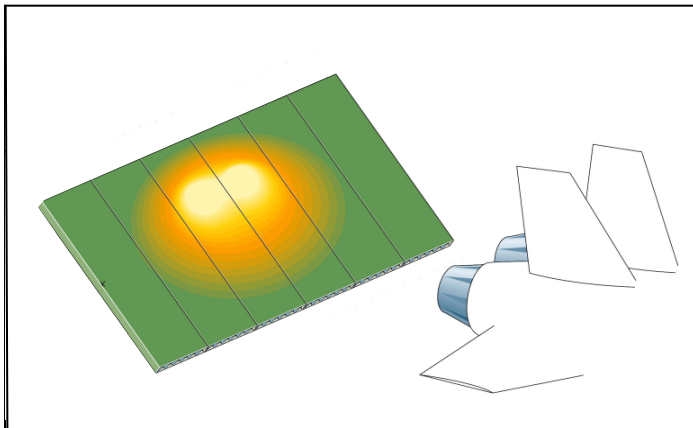
Jet Noise Reduction (JNR) Project FY10 Tasks



Noise Induced Hearing Loss

Primary Tasks

- **Noise Measurement Standard**
 - Develop a Mil/ANSI standard for measurement of noise emitted by high performance military jet aircraft
- **Modeling and Simulation/Validations**
 - Improve understanding of physics of jet noise
 - Develop validated, high-fidelity, modeling and simulation capability
 - Assess jet noise reduction concepts
- **Jet Blast Deflector Scaled Tests**
 - Scaled test w/ existing nozzle and chevrons
 - Measure effect of presence of JBD
- **F-35 Noise Reduction Concepts**
 - Identify promising noise reduction concepts



Other Relevant Research

- **Small Business Innovative Research (SBIRs)**
 - Acoustic measurement
 - Computational methods
 - Lower order models
- **Defense University Research Instrumentation Program (DURIP)**
 - Instrumentation improvement to measure novel concepts
- **Young Investigator Program (YIP)**
 - Upstream influences on jet noise



Supporting University Research



Noise Induced Hearing Loss

Jet Noise Reduction

Young Investigator's Program (YIP)

- “Detailed Modeling of Core Noise Contributions to Jet Engine Noise Using Large-Eddy Simulation and Acoustic Theory”
 - Advances understanding of direct and indirect contributions of combustion-generated noise from low-bypass aircraft engines
 - Hybrid model to be developed (based on the Large-Eddy Simulation (LES) technique)



Prof. Matthias Ihme
University of Michigan

Defense University Research Instrumentation Program (DURIP)

- “Instrumentation for Jet Noise Mitigation in Tactical Aircraft Using Plasma”
 - Developed a new class of plasma actuators - Localized Arc Filament Plasma Actuators (LAFPAs)
 - Proven to be effective for noise suppression in subsonic and supersonic jets
 - Extending prior focus on jet noise reduction for commercial applications (where either shock noise is either non-existent or at best very weak) to noise mitigation in tactical aircraft



Prof. Mo Samimy
The Ohio State University



FY11 Basic Research Challenge Topic



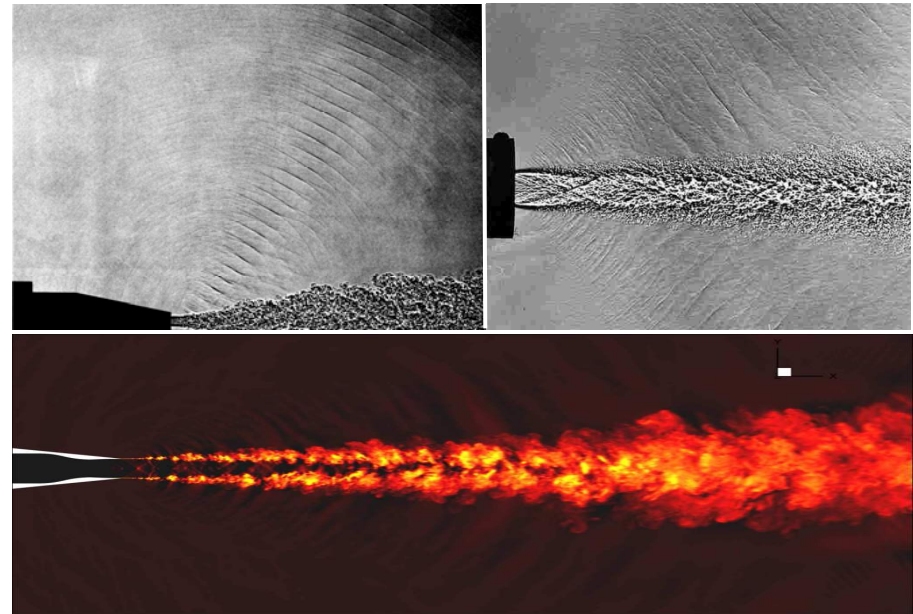
Noise Induced Hearing Loss

Jet Noise Reduction

Towards Active Control of Noise from Hot Supersonic Jets

Objective:

- Understand the physical mechanisms behind the growth and control of large scale turbulent structures in hot supersonic jets and their impact on noise generation



Approach

- Reduce noise by reducing deleterious large-scale turbulent structures
 - Enhancing turbulent structures less efficient at generating noise
 - Suppressing turbulent structures and those more efficient at generating noise
 - (Opportunity to act on the instabilities at the exhaust nozzle exit lip where shear layers are most receptive and impact to the system is minimal)

Specific Research Required:

- Analytical and computational approaches
- Connections between flow and noise radiation
- Advanced noise control
- Advanced diagnostics and experiments

Next Steps:

- Announcement requesting responses to ONR's Long-Range BAA
- Proposals awards expected 3rd Qtr FY11



Summary



Noise Induced Hearing Loss

Jet Noise Reduction

Department of Navy Jet Noise Reduction (JNR) Project

- As part of the Noise Induced Hearing Loss Program, the JNR Project is addressing key aspects of a comprehensive plan for reducing jet noise
- The JNR Project will advance the theoretical understanding of jet noise via advancements in validated modeling and simulation combining subscale (i.e. laboratory-scale) and full scale testing
- The JNR Project's metrics include reducing noise by 3 dBA within five years and by 10 dBA within 10 years
- Recent award of an ONR Basic Research Challenge topic substantially bolsters this effort
- Transition opportunities through ONR's Future Naval Capabilities are being pursued